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Quarterly Status Report #2

"Investigation of New Systems for Potential Laser Action"

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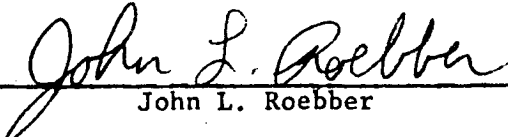
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I. Purpose of This Research

The purpose of this research is to find new chemical systems which can exhibit laser action. Metal compounds which can undergo photo-dissociation have been selected as the most promising candidates for laser applications. The project involves the spectroscopic study of selected metal derivatives, the characterization of any chemical changes which occur on their photolysis, and the performance of cavity experiments for the detection of laser action.

II. Research Activities Undertaken and Planned

During this quarterly period, we have been engaged in finding whether I ($^2P_{1/2}$) is produced in sufficient quantities to produce detectable fluorescence when HgI_2 is photolyzed in its 2660 Å absorption band and in studies of the emission spectra produced in the vacuum ultraviolet regions when metal halide vapors are excited by a microwave discharge.

A. Gas Phase Fluorescence from HgI_2 Photolysis Products

Iodine atom emission when HgI_2 is illuminated in its 2660 Å band has been looked for at 1.315 microns using a Block Model 200S Interferometer Spectrometer as the analyzing instrument. No emission has been observed despite every effort to increase the sensitivity of the experimental arrangement. A medium pressure mercury arc was used as the exciting light source. Both a monochromator and a $NiSO_4-CoSO_4$ filter were used to isolate the 2537 and 2660 Å lines from the mercury arc. Measurement with a potassium ferrioxalate actinometer showed that 1.10×10^{15} quanta/sec fell on the sample when the chemical filter was used and 7.9×10^{14} quanta/sec when

the monochromator was used. The temperature of the sample cell was varied between 150 to 225°C in order to change the amount of light absorbed by the HgI_2 . However, most of the runs were carried out at a temperature such that about 88% of the incident light was absorbed. Since $\text{I } ({}^2\text{P}_{1/2})$ has a half-life of 0.13 sec, several experiments were carried out in which 15 to 20 cm Hg pressure of helium were added to slow diffusion of the excited iodine atoms to the walls. All of these efforts failed to produce sufficient emission to detect.

There are two possible explanations for the failure of these experiments. Either no excited iodine atoms are produced when HgI_2 is irradiated in its 2600 Å absorption band, or excited atoms are produced but are quenched before they have time to emit. In order to estimate an upper limit on the number of excited iodine atoms which are produced, the sensitivity of the Block Interferometer Spectrometer at 1.315 microns must be known. Such measurements are now in progress.

B. Microwave Excitation Experiments on Metal Halides

The emission spectra in the 2100-1600 Å region when HgI_2 , HgBr_2 , PbI_2 , and PbBr_2 are separately subjected to a microwave discharge have been recorded. The spectra from HgBr_2 , PbI_2 and PbBr_2 were obtained in order to aid in identifying the bands observed from HgI_2 . A number of bands were found to be common to both the HgI_2 and HgBr_2 spectra, but not to the PbI_2 or PbBr_2 spectra. These common bands may be due to mercury, but since Hg_2 does not

have a bound ground state, they are probably due to some common impurity. These common bands in the 1600-1800 Å region are shown in Fig. 1 and listed in Table I.

A large number of bands appear in the spectrum of a microwave discharge through HgI_2 in the 1850-2100 Å region which do not appear when HgBr_2 , PbI_2 , or PbBr_2 are used. These bands, which are spaced about 7 Å apart, are shown in Fig. 2. The most regularly spaced of these bands are listed in Table II. These bands may be due to HgI .

Caution must be exercised in assigning these bands to HgI , however. Haranath and Rao (J. Mol. Spectr. 2, 428 (1958)) have reported a series of bands extending from 1950-1790 Å in emission from I_2 upon excitation by a condensed discharge or a R. F. discharge. Unfortunately, these authors do not list the wavelengths of these bands and the reproductions of their spectra in their article are too blurred to show them. Very careful experiments with I_2 will have to be carried out before we can rule out I_2 as a possible source of these bands. Of course, unknown impurities may also be the cause of these bands rather than HgI .

To help in the assignment, the microwave apparatus is being modified so that a large excess of inert gas (helium or argon) can be used to quench the emitting species down to its lowest vibrational level in the excited electronic state. This should greatly simplify the resulting emission spectra. These experiments are in progress now.

We are continuing our work on the radio-frequency excited spectra of HgI. It became obvious to us that we needed more R. F. power than was available from the 40 watt transmitter we had been using. We now are able to make use of an 80 watt transmitter which is amplified to 800 watts by a linear amplifier. This created a very bright discharge in the HgI₂ vapor. Provision for adding an inert gas has also been made in the R. F. apparatus. No new spectra have been obtained yet with this more powerful source because of enormous pickup by our detector circuits from the transmitter. Double shielding has now been built around the R. F. source, which should eliminate this problem.

" Table I.

<u>Band Label</u>	<u>λ Å</u>	<u>ν (cm⁻¹)</u>
1	1811.47	55,203.8
2	1805.73	55,379.3
3	1793.43	55,759.1
4	1775.37	56,326.3
5	1748.18	57,202.3
6	1743.75	57,347.7
7	1730.32	57,792.77
8	1724.55	57,986.1
9	1712.57	58,391.8
10	1705.52	58,633.1
11	1688.46	59,225.6
12	1686.99	59,277.2

Table II. Emission bands from a microwave discharge through HgI_2

Band Label	Wavelength " $\overset{\circ}{\text{A}}$	Wavenumber cm^{-1}	Difference cm^{-1}
1	1856.2	53,873	
2	1863.9	53,650	223
3	1871.5	53,433	217
4	1878.5	53,234	199
5	1886.4	53,010	224
6	1893.8	52,804	206
7	1901.1	52,600	204
8	1909.2	52,379	221
9	1916.8	52,170	209
10	1924.2	51,970	200
11	1933.0	51,732	238
12	1939.4	51,563	169
13	1947.2	51,355	208
14	1952.0	51,231	124
15	1959.3	51,039	192
16	1964.5	50,904	135

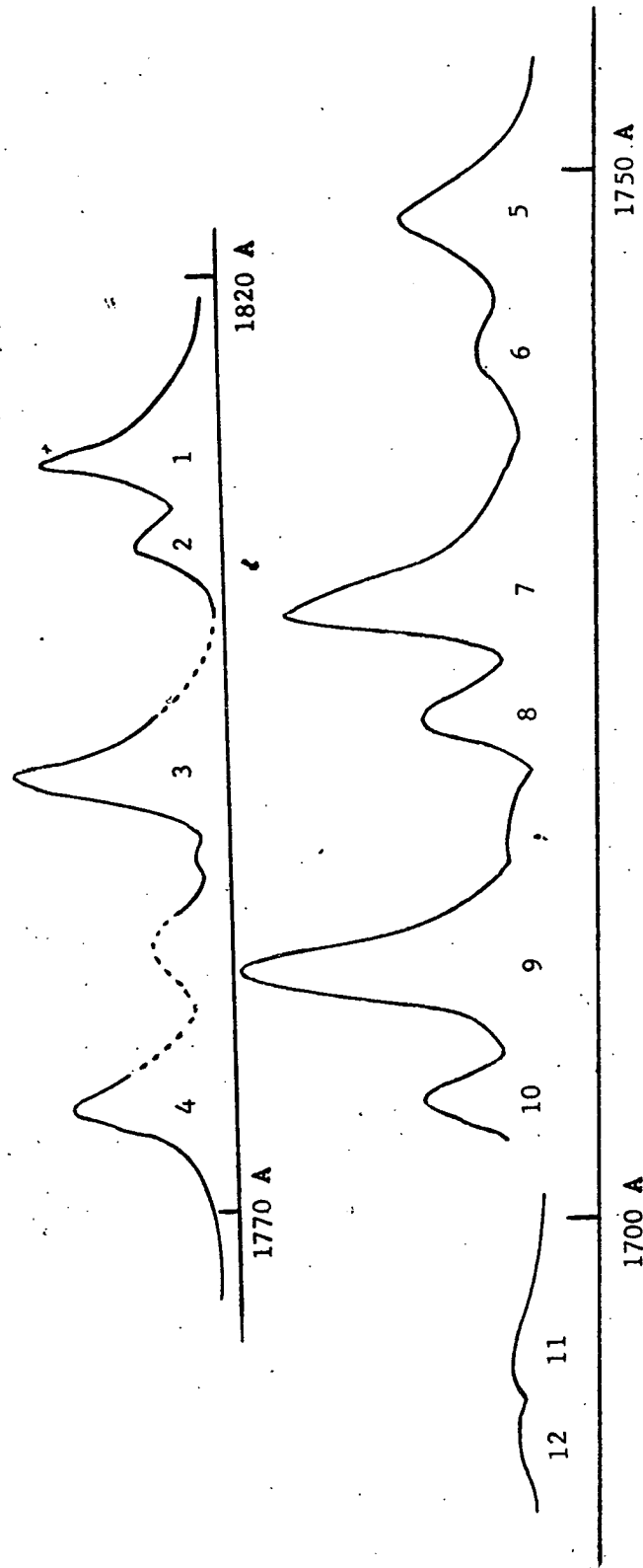


Fig. 1. Emission spectrum of 2 microwave discharge through HgI₂ 1600-1800 Å region.

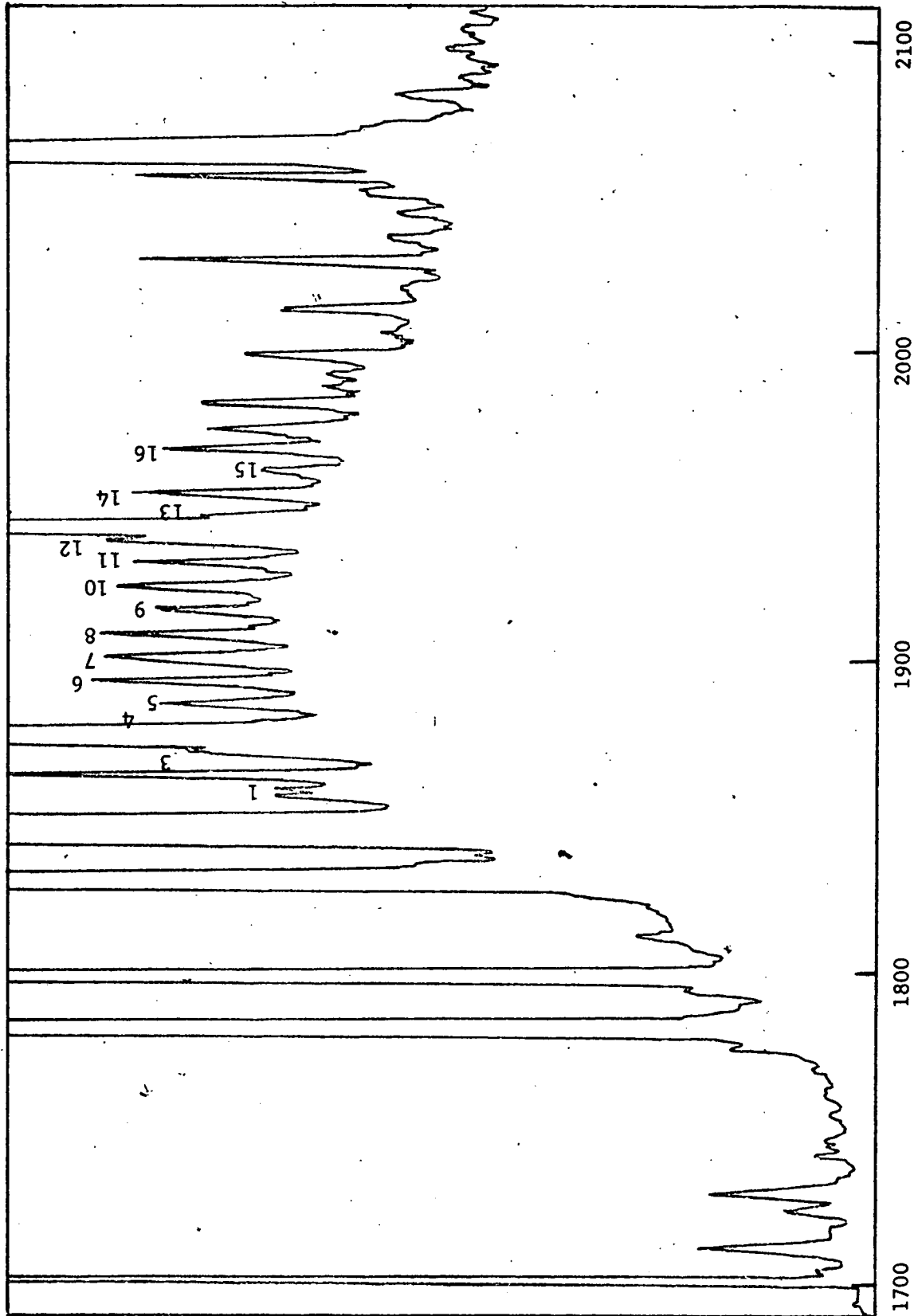


Fig. 2. Emission spectrum of a microwave discharge through HgI_2 1800-2100 Å region.